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STORAGE

THE CONSTRUCTION OF DRAIN GAUGES AT PUSA

BY

M. H. ARNOTT, Esq., M.INST.C.E

Superintending Engineer, P.W.D

TOGETHER WITH A PREFACE ON THE USE OF SUCH GAUGES

BY

Dr. J. WALTER LEATHER, Ph.D., F.I.C

AGRICULTURAL RESEARCH INSTITUTE, PUSA

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PREFACE.

In this Memoir Mr. Arnott gives details of the cost of four drain gauges which have been constructed at Pusa. The detailed drawings and the photographs illustrate completely the method adopted.

It will be of interest if, to this description, is added a note of the principal uses to which these gauges may be put.

If such blocks of earth, as are referred to, are isolated, then the water which percolates through them during wet weather may be measured and compared with the rainfall ; it may also be examined chemically. It is possible in this manner to obtain data regarding the following :—

(*a*) The amount of water which percolates per unit of time and its relation to the rainfall.

(*b*) The amount of water flowing off the surface during storms.

(*c*) The proportion of the rainfall which evaporates.

(*d*) The effect which growing plants exert on these proportions.

(*e*) The amount of any plant foods which pass away in such drainage water.

The most complete records which have been maintained in other countries on this subject are those at Rothamsted, which extend over a period of 30 years, and admit of the following deductions being drawn :—

(1) The amount of percolation in any year varies directly with the rainfall ; thus with a rainfall of 41 inches the percolation was about 25 inches, with a rainfall of 19·5 inches percolation was 6 inches.

(2) The amount of evaporation is very nearly constant, and is slightly greater in wet years than in dry ; thus in the two years referred to, with a rainfall of 41 inches the evaporation was about 16 inches, whilst with the rainfall of 19·5 inches the evaporation was about 13 inches. This is the opposite of what is usually supposed and is probably due to the fact that the greater part of the evaporation occurs immediately after rain.

Regarding these two points we have a certain amount of information also in India. Four gauges were constructed at Cawnpore in 1903, and the four years' data go to show very clearly that the conclusion arrived at from the Rothamsted gauges will be confirmed here also. The following statement embodies the chief items relating to this part of the subject : --

Period.	Rainfall.	Percolation.	Overflow.	Evaporation.
June 1903—October 1903 ...	26·14	11·55	*Nil.*	14·59
October 1903—October 1904 ...	45·66	25·58	4·0	16·08
October 1904—October 1905 ...	20·62	3·03	*Nil.*	17·59
October 1905—October 1906 ...	36·50	18·72	*Nil.*	17·78

It will be seen that (*a*) the amount of percolation varies directly with the rainfall ; (*b*) the amount of evaporation is fairly constant.

Regarding the surface flow during storms, provision is scarcely necessary for this in Europe where nearly the whole of the rainfall is absorbed by the land directly. In India it is clear that during heavy falls of rain which are so common, some water flows off the land. The Pusa gauges have been provided with means of measuring the amount of this overflow of storm water.

In reference to the composition of the drain-gauge water, the chief factor which is being recorded at Rothamsted is the amount of nitrate. Those gauges are kept free from vegetation and the quantity of nitrate which has been carried away is equal to about 30 lbs. of nitrogen per acre per annum. The Cawnpore gauges have yielded very much larger amounts of nitrate ; this

soil had been heavily manured for some years previous to the construction of the gauges, and this large amount of nitrate is no doubt readily accounted for in this manner. The gauges at Pusa have been made in land which has not been either cultivated or heavily manured for a long time, and the amount of nitrate present in the drainage water last year was very small.

The effect of plants growing on such gauges would be undoubtedly to use up much of the water and plant food which percolates in the absence of vegetation. How great this effect is, has so far been ascertained in only a very general way ; the intention is, however, to grow crops and grass on some of the Pusa gauges and so obtain data in this direction also.

There can be no doubt that information obtained by drain gauges is of very great importance, especially in India where practically nothing is known at present of what becomes of the rain which falls on the land, and observations by means of them in different places is highly desirable.

J. WALTER LEATHER.

PUSA ;
July 1907.

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THE CONSTRUCTION OF DRAIN GAUGES AT PUSA.

BY

M. H. ARNOTT, M.INST.C.E.,

Superintending Engineer, P. W. D.

It has been thought that a paper detailing the construction of the drain gauges lately made at Pusa might prove of use in case others at any time may have to be constructed, and as they were built under the writer's supervision, he has been asked by Dr. Leather, Imperial Agricultural Chemist, to write such a paper. The problem to solve was to cut out from the original soil an irregular cube of earth 7 ft. 4 in. long by 6 ft. broad and 6 ft. or 3 ft. deep, support it and enclose it with masonry walls and in so doing prevent any cracks from occurring. The existence of cracks would make the gauge useless, so the problem was one of considerable practical difficulty. After a good deal of consideration and discussion it was determined that the best way to do the work was to make an experimental gauge on the following lines :—

(i) To cut a trench some 12 or 13 ft. deep on both sides of the irregular cube, as shown in Plate I, finely dressing the sides of the earth between the two trenches where the gauge was to be, (ii) to make holes as shown in Plate No. II right through the thickness of the gauge, and (iii) into which would be inserted mild steel joists, supported as shown in Plate No. III ; (iv) having inserted the joists and supported them on both sides, to "jack" in mild steel plates between the top of the joist and the earth,

operating from both sides of the gauge. If the plates could be got home by means of the screw jacks so that the whole of the superincumbent earth was supported, and this without cracking the soil or tearing away portions of it, the problem was practically solved, for the rest of the operations required only very careful treatment.

It would have been impossible to have got one plate 8 ft. 7 in. by 9 ft. 2 in. into position over the joists owing to its excessive weight, so the writer settled to use six plates as shown in Plate XVIII. The experimental gauge showed that this could be done, and three plates having been successfully placed in position, further operations were stopped and work was commenced on the four gauges that had to be built, two with a 6-ft. and two with a 3-ft. depth of earth. Before describing the construction in detail, it will be of interest to describe a completed drain gauge and to note the calculations necessary for arriving at the proper sections for the mild steel joists, their number, thickness of plates, etc.

Description of a 6-ft. Drain Gauge.

As has been mentioned before, the earthen gauge is to be surrounded by masonry for a depth of 6 ft. or 3 ft. Below this depth, three of the masonry walls only are carried down, but the fourth wall stops at plate level so as to allow entry into this underground chamber in which the drums for collecting water are to be placed, and the amount so collected read off by the observer. This means that on this fourth side the joists and plates must be supported by a bressummer which in its turn is supported by the two side walls as will be noticed in Fig. 2, Plate IV. Plates IV and IV^1 show plan and sectional elevations of a 6-ft. gauge. Below this bressummer it was settled that a 6-ft. space to concrete floor level would be sufficient, making a total height of 13 ft. 2½ in. from ground level. To get down to the chamber, a well, provided with a fixed ladder, was made as shown in Fig. 3, Plate IV^1, and to prevent rain water getting in, the top of the well is provided with

two corrugated iron half doors. It would have been better to have used flat iron plates as doors as it has been found that frogs enter, owing to the folds in the former, die in the well and have to be removed. The plates placed above the joists are perforated with half inch diameter holes, six inches apart from centre to centre, over the whole superficial area of 7 ft. 4 in. by 6 ft. 0 in. or $\frac{1}{1000}$th of an acre. The water coming through the perforated plates is collected by means of a collecting plate with a funnel, made of galvanized sheet iron, a plan of which is shown in Fig. 4, Plate IV[1]. This is fixed into the walls with a slope from back to front and the method of attachment is depicted in Fig. 5, Plate IV[1]. Fig. 6, Plate IV[1], is a mud hole in the collecting plate so that the space between it and the perforated plates may be cleaned out at any time. The drain gauge chamber, in which the drums are placed, is also provided with a corrugated iron door and its three walls are all buttressed as explained further on. In order to render the floor as it was hoped, water-tight, 2-in. stone flagging was placed above the concrete floor, but still the water comes up to a depth of 4 in. through the junction between the stone. This has been found from the experience of this year's rains. It will be necessary to cover the whole floor with a further thickness of 1 in. Indian Patent Stone, which should have the desired effect It is imperative that no water should be able to percolate from the outside of the masonry into the gauge, as this would vitiate the whole of the results, so between the sides of the earthen cube and the brickwork, 3 in. of cement concrete is provided. This is shown in Figs. 2 and 3, Plates IV and IV[1]; in Plate No. V this small edging of concrete between the brickwork and earth may be noticed. In addition the whole of the brickwork inside and outside is cement plastered. The masonry walls are carried 5 in. above the ground surface of the drain and are made to slope outwards. In one wall are placed three one-inch overflow pipes, two. three and four inches, respectively above ground level, and leading into a small overflow chamber 3 ft. 5 in. by 3 ft. 5 in. and 2 ft. in depth. Each pipe is provided with a cock. The above is shown in Plate No. VI.

Calculations necessary to determine the Dimensions of the Joists, Plates, Thickness of Walls, etc.

The bressummer joist bears half the weight of the earth, the cross joists and the plates, and the front portion of the masonry, and, as is seen by the calculations in Appendix A, a joist of 9 in. by 4 in. is sufficiently strong for the load it has to carry.

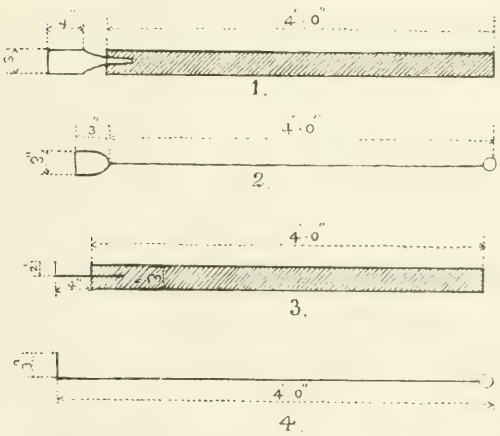
The cross joists bear the weight of the earth and the weight of the plates. Five joists were used so that the space between each joist might be 1 ft. 9 in., this space being regulated by the size of the plates. To have had fewer joists would have meant a greater distance between each joist and therefore bigger and consequently heavier plates, for it is essential that the plates must have their ends resting on the joists as is seen in Plate VII. The calculations in Appendix B show that joists 5 in. by 3 in. are strong enough. The perforated plates are $\frac{1}{2}$ in. thick according to the calculations in Appendix C; this thickness is far in excess of requirements, but owing to the numerous perforations, the strength of the plates is considerably reduced, so for safety's sake $\frac{1}{2}$ in. plates were used. The pressure on the foundations was taken at 0·7 of a ton per sq. ft., the permissible for Bengal being 1 ton per sq. ft. ; the calculations are given in Appendix D. The calculations for the joists and plates are based on the commonest case in Applied Mechanics of a beam supported at the both ends and loaded throughout its length with an evenly distributed load.

During the construction of the walls it struck the writer to see if the earth pressure rendered the structure unstable and it was found that the centre of pressure fell outside the base, so it was necessary to buttress the three walls. The calculations are given in Appendix E.

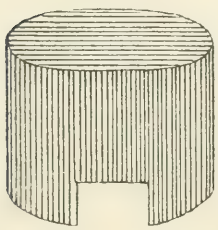
Construction of a 6-ft. Drain Gauge.

It would not have been safe to have cut the trenches out as shown in Plate I so as to have left exactly 6 ft. of earth between them, as this would allow of no margin for any small accidents that might occur, such as, say, 3 inches of soil falling away from

the face, so the dimensions of the drain gauge, as already noted, being 7 ft. 4 in. by 6 ft., an area of 8 ft. 10 in. by 7 ft. 6 in. was pegged out by means of the theodolite, thus leaving a 9 in. margin on each side. The two trenches on both sides of the 7 ft. 6 in. breadth were then excavated to a depth of 13 ft. and for a length of 17 ft. As the work descended, a ramp was made on both sides. The two faces of the gauge were then very finely and carefully dressed by the masons and the positions of the joists marked on them. The vertical distance from ground level to the top of the joist was 6 ft. 0½ in., and each joist was to be 1 ft. 9 in., centre to centre, from the other, so their positions were easily fixed. The five joist holes 1 ft. square had then to be drilled through the 7 ft. 6 in. length, and this had to be done by masons and not by coolies. For the purpose, the four tools, of which sketches are given below, were used.



No. (1) is used for digging out the holes, No. (2) for dressing the four angles of the holes, No. (3) is used for dressing the top surface of the holes roughly horizontal, and No. (4) for making the same truly horizontal. Plate II shows how accurately this work was done by the masons. After the joists have been inserted into the holes, Plate II, they are supported as shown in Plate III, that is, by two 2-inch "sal" boards. These boards rest on props, the lower ends of which lie on another 2 in. "sal" board, and this latter rests on ground that has been thoroughly rammed and consolidated to obviate any chance of settlement when the full load comes on. A groove, as in sketch, is made in the lower end of the props into which wedges are inserted and driven home so as to ensure that the upper ends of the props are really pressing against



the "sal" boards. Plates VIII and IX show geometrically the holes and the joists inserted. Plate X the joists propped and the structure ready for the insertion of the plates. Plates VII and XI show the plates supported, and the jacks in position. The operation is commenced from one end, and when one plate is driven in, the opposite plate on the other side is next jacked in, and so on until the whole six plates are fixed *in situ*.

The secret of success is, firstly to see that each plate during the operation is kept perfectly horizontal, both longitudinally and transversely, and for this purpose frequent use must be made of the spirit level ; secondly, that the levers of the two jacks are invariably turned simultaneously and for the same distance, so that the plate may be driven in evenly. To ensure this, after every turn of the jacks, the distance between the edges of the plates and the edges of the joists on which it rests, must be measured to see that they agree. If there is any difference, this must be adjusted by turning one jack and not the other. After the plate is in position and properly levelled and tightened up by the screw jacks, before they are turned a piece of earth six inches in thickness is removed from underneath the joist to a depth of about 1 ft. 6 in. just sufficient, eventually to allow a man to crouch in and remove the earth for half-an-inch above the joists. This is done by means of the scraper of the shape shown in sketch 3 in the previous paragraph. The cutting out of this half inch is done carefully and as truly level as possible. After the plates have been driven in this six inches, another six inches is removed in similar fashion, and this goes on till the plate is jacked home. When two opposite plates are getting close together, the screw jacks must be turned very gently, for the plates must not be allowed to touch each other and a clearance of a quarter-of-an-inch is left. In pushing in the plates should one abut against the other, it will set up, at the time of contact, great internal vibration in the block and most likely produce cracks or cause portions of the block to shear off. This was noted in the experimental gauge. When all the plates are in position, it is necessary to test whether the earth is everywhere resting evenly on them, and this can be done by measuring the depth from the

bottom of the earth to the bottom of the plates by means of the perforations in the latter. If this depth is more than half an inch, it shows that the plates are not pressing up against the earth and they must be wedged up with iron wedges, placed between the bottom of the plates and the top of the joists, so that they may do so. For making the joist holes, placing the joist in position and propping them, 1 head mason, 4 masons and 6 coolies will do the work in two days, and the same number of men in the same time will completely drive the plates home as soon as they get a little experienced. Unless the placing of the plates under the gauge is most carefully supervised by an Engineer and not left for a single moment to the masons, the operation will be a failure, so unless an entirely reliable man's whole time can be given up to this, it is better not to attempt it. After the plates are in, the rest of the earth is removed to the required depth and the joists and plates are further shored up by three rows of "sal" props in the same manner as was described for the end props. This shoring is shown in Plate XII. The whole of the gauge being now supported, the props at the back are removed, the foundations of the back wall dug, concrete laid and consolidated, and after it has set, the back masonry wall is constructed to the bottom of the joists, they resting securely on the masonry by means of $\frac{3}{8}$in. bed plates. The front row of props is then removed and the bressummer joist placed in position and kept there by bamboo props, care being taken to see that the joist is exactly level. After this has been done, the two open sides of the gauge are supported horizontally to prevent any lateral displacement, the earth on the uncut sides is then excavated to proper depth, the supports to the first two sides removed temporarily and the whole gauge brought to its proper dimensions, namely, 7 ft. 4 in. by 6 ft. 0 in., by fine dressing by the masons. Plate XIII shows this operation completed. The gauge is again shored in the manner depicted in Plates XIV and XV. Plates XVI and XVII also show the same treatment for one of the 3-ft. gauges ; here, as the soil was more friable, close shoring was resorted to. The brickwork of the remaining walls is then proceeded with, till eventually the whole gauge is enclosed

in masonry as is seen in Plate V. This having been successfully accomplished, the rest of the construction calls for no detailed description. It consists in simply building the floor of the chamber, fixing the collecting plate, building up the well and the ladder at the same time, fixing the doors and constructing the overflow reservoir. Great care should be taken to see that the masonry is as well made as possible, all joints being thoroughly filled up with mortar, and still more care should be taken at all junctions. The filling of the trenches also requires attention, and the earth should be rammed in six-inch layers.

Cost of a 6-ft. Drain Gauge.

The total cost of a 6-ft. Drain Gauge as actually constructed comes to Rs. 1,138 with the rates that obtain at Pusa. In Appendix F is given an abstract of the expense showing the quantities or numbers of each sub-head, its rate and cost.

APPENDIX A.

Calculation for determining the size of the Bressummer Joist.

Bressummer joist at entrance.

Total load on this beam

$$= \frac{\text{wt. of earth}}{2} + \text{wt. of top portion of the masonry} + \frac{\text{wt. of plate}}{2} + \frac{\text{wt. of 5 joists}}{2}$$

$$= (7' 4'' \times \tfrac{6}{2} \times 120 \times 6' 0'' + 7' 4'' \times 1' 6'' \times 120 \times 6' 0'') + (4' 6'' \times 7' 4'' \times 20) + (5 \times 4' 6'' \times 11) \text{ lbs.}$$

$$= 23{,}760 + 660 + 247 \text{ lbs.}$$

$$= 24{,}667 \text{ lbs.}$$

$$Mf = \frac{W\ l}{8} = \frac{24{,}667 \times 7 \times 12}{112 \times 20 \times 8} = 115{\cdot}6 \text{ inch tons.}$$

Take a section 9″ × 4″ @ 21 lbs.

$$Mr = \frac{P \times I}{y} = \frac{7{\cdot}5 \times 81{\cdot}52}{4{\cdot}5} = 135{\cdot}8 \text{ inch tons.}$$

So this section may be used leaving a good margin of safety.

APPENDIX B.

Calculation for determining the size of Cross Joists.

$$M_f = \frac{W\ l}{8}$$

$$= \frac{6'\ 11'' \times 12\ (1{\cdot}75 \times 6'\ 11'' \times 6'\ 0'' \times 120 + 6'\ 11'' \times 1{\cdot}75 \times 20)}{8 \times 112 \times 20}$$

$= 41{\cdot}4$ inch tons.

Take a section $5'' \times 3''$ @ 11 lbs.

whose $M_r = \frac{P \times I}{y} = \frac{7{\cdot}5 \times 13{\cdot}69}{2{\cdot}5} = 41{\cdot}07$ inch tons.

So this section may be used.

APPENDIX C.

Calculation for determining the thickness of Mild Steel Plate.

Take a strip 1 foot say. The load on this strip

$= 1{\cdot}75 \times 1 \times 6'\ 0'' \times 120$ lbs.

$$M_f = \frac{1 \times 1{\cdot}75 \times 6 \times 120 \times 21}{8 \times 112 \times 20}$$

$= 1{\cdot}5$ inch tons.

Take a section $\frac{1}{2}''$ thick.

$$M_r = \frac{P \times I}{y}$$

$I = \frac{1}{12}\ bd^3$.

$= \frac{1}{12} \times 12 \times {\cdot}5 \times {\cdot}5 \times {\cdot}5$

$= {\cdot}125$

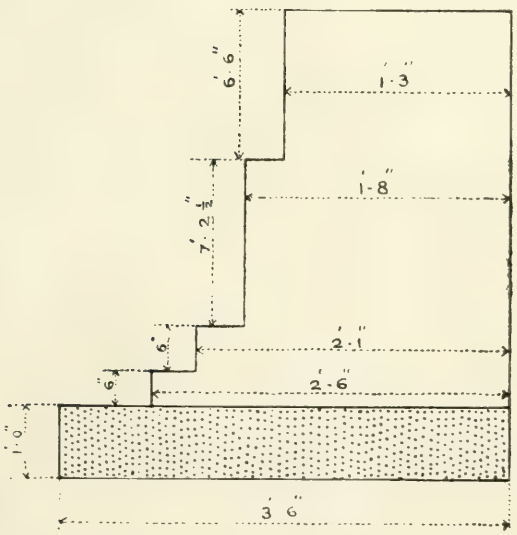
$$= \frac{7{\cdot}5 \times {\cdot}125}{{\cdot}25} = 3{\cdot}75 \text{ inch tons.}$$

APPENDIX D.

Calculation to ascertain the thickness of the Foundations.

The walls are to be built first and they will bear the full load before the buttresses can be constructed, as the props cannot be removed. The whole weight, therefore, falls on the base of the walls. The buttresses merely help to resist the earth pressure when the filling is completed. The walls are in consequence designed to bear the superincumbent weight of earth and masonry independently of the buttresses.

Extreme Case taken.



Wt. of masonry—

$1 \times 6' \ 6'' \times 1' \ 3'' = \ 8{\cdot}12$

$1 \times 7' \ 2\frac{1}{2}'' \times 1' \ 8'' = 12{\cdot}00$

$1 \times 0' \ 6'' \times 2' \ 1'' = \ 1{\cdot}04$

$1 \times 0' \ 6'' \times 2' \ 6'' = \ 1{\cdot}25$

$1 \times 3' \ 6'' \times 1' \ 0'' = \ 3{\cdot}50$

$= 25{\cdot}91$

Wt. of earth—

$1 \times 3' \ 3'' \times 6' \ 0'' = 19{\cdot}50$

$= 45{\cdot}41$

$$= \frac{45{\cdot}41 \times 120}{112} \text{ cwts.}$$

$= 48{\cdot}65$ cwts.

$= \ 2{\cdot}43$ tons.

Pressure $= \frac{2{\cdot}43}{3{\cdot}5} = \ {\cdot}7$ tons nearly which may be allowed as the soil below 15′ 0″ is softer than the top soil.

The earth pressure is obtained from the formula :—

$$P = \frac{w}{2} \frac{H^2}{} \times \frac{1 - \text{Sin} \propto}{1 + \text{Sin} \propto}$$ where $\propto$ = angle of repose of the soil.

In this case taken at 54° as it is moist earth.

$$= \frac{120 \times 13{\cdot}20 \times 13{\cdot}20}{2 \times 112} \times \frac{1 - {\cdot}80}{1 + {\cdot}80}$$

$$= 10{\cdot}26 \text{ cwt.} = {\cdot}5 \text{ tons.}$$

The earth pressure acts at $\frac{2}{3}$rds the height of the wall and is horizontal. The diagonal of the parallelogram in Plate XIX is the resultant of the two forces, and is seen to fall outside the wall. This shows that the wall is unstable when the earth pressure exerts its full force. To make it stable a buttress is necessary.

The following are the calculations after adding in the buttress :—

There are now three parallel forces, the centres of gravity of which act at different points.

The forces are :—

(i) the weight of the top block of masonry

$$= 1 \times 6' \ 6'' \times 1'3'' = 8{\cdot}12 \times \tfrac{120}{112} = 8{\cdot}70 = {\cdot}43 \text{ ton.}$$

The centre of gravity of this passes through the middle of the 1′ 3″ wall.

(ii) The weight of earth $= 1 \times 3' \ 3'' \times 6' \ 0'' = 19{\cdot}50 \times \tfrac{120}{112} =$ 1 ton.

The centre of gravity of this passes through the centre of the 1′ 8″ wall.

(iii) The weight of the bottom portion of masonry after adding the buttress :—

This is taken as a trapezium.

$$1 \times \frac{1' \quad 8'' + 4' \quad 1''}{2} \times 7' \ 2\tfrac{1}{2}'' \times \tfrac{120}{112} = 22{\cdot}14 = 1{\cdot}1 \text{ ton.}$$

The centre of gravity of this has been worked out graphically, see Plate XX.

There are now three like parallel forces and their resultant is equal to 2·53 tons.

The point of application of the resultant is found diagrammatically, Plate XX.

The main component forces have now been ascertained, namely, the pressure of earth acting at $\frac{2}{3}$rds the height of the wall and the resultant of all the vertical pressures. The resultant of these two forces is also ascertained as in the first case by drawing a parallelogram with a scale of load of 1 ton = 1″.

This resultant falls within the middle third of the base which shows that the structure is stable.

APPENDIX E.

Calculation to determine if the walls require Buttresses or not.

The weight of earth and superstructure masonry are as follows :—

Weight of top portion $= 1 \times 6' \ 6'' \times 1' \ 3'' = \dfrac{8{\cdot}12 \times 120}{112}$

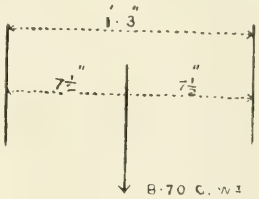
$= 8{\cdot}70$ cwt.

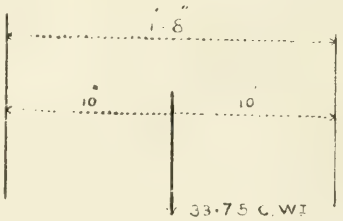
Weight of bottom portion $1 \times 7' \ 2\frac{1}{2}'' \times 1' \ 8'' = 12{\cdot}00$,,

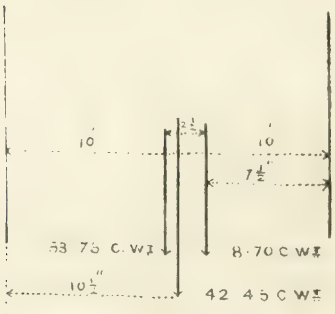
Weight of earth $= 1 \times 3' \ 3'' \times 6' \ 0'' = \dfrac{19{\cdot}50}{31{\cdot}50} \times \frac{120}{112}$,,

$= 33{\cdot}75$ cwt.

The centre of gravity of the top portion passes through the middle of the $1' \ 3''$ wall and the centre of gravity of the bottom portion together with the weight of earth passes through the middle of the $1' \ 8''$ wall. Now there are two like forces acting at different points of the same wall. The magnitude of the resultant will therefore be equal to their sum $= 42{\cdot}45$ cwt. $= 2{\cdot}12$ tons, and the point of application is $10\frac{1}{2}''$ from the outer face of the wall, thus :—







The distance between the points of application of the two forces is $2\frac{1}{2}''$. Let x be the distance of the resultant from the first force, then we have $33{\cdot}75 \times = 8{\cdot}70 \ \ (2{\cdot}5 = \times)$ from which we get $x = \frac{1}{2}''$; therefore the resultant is situated $10\frac{1}{2}''$ from the outer face.

APPENDIX F.

Details of cost of a 6-foot Drain Gauge.

Quantity or No.	Abstract of expense.	Rate. Rs.	As.	P.	Per	Amount. Rs.	TOTAL. Rs.
1. 5,230 c. ft.	Earthwork in excavation ...	5	0	0	0/00	26	
2. 3,356 c. ft.	Earthwork in filling ..	2	0	0	0/00	7	
3. 1 set.	Extra labour for pushing in the bed plates	45	0	0	L. S.	45	
4. 170 c. ft.	Concrete in foundation with lime mortar	18	0	0	%	31	
5. 127 c. ft.	Extra cement in concrete for foundations	2	0	0	%	3	
6. 1,241 c. ft.	Brick in lime	23	0	0	%	285	
7. 506 s. ft.	Cement plaster, $\frac{1}{4}$″ thick	6	0	0	%	30	
8. 143 s. ft.	Cement plaster, $\frac{1}{2}$″ thick	12	0	0	%	17	
9. 38 s. ft.	2″ Sand stone flagging	33	0	0	%	13	
10. 15·49 cwt.	$\frac{1}{2}$″ Mild steel plate	11	8	0	cwt.	178	
11. 1·5 cwt.	$\frac{3}{8}$″ Wrought iron bed plate ...	11	0	0	cwt.	17	
12. 1 set.	Fixing in the bed plates	1	0	0	L. S.	1	
13. 6·45 cwt.	Mild steel joists	8	12	0	cwt.	57	
14. 41·5 c. ft.	Cement concrete	55	0	0	%	23	
15. 168 Nos.	Making holes in plate	0	3	0	each	32	
16. 1 set.	Coal tarring and painting to joists ..	2	0	0	L. S.	2	
17. 1·33 cwt.	W. I. work in ladders	15	0	0	cwt.	20	
18. 54 s. ft.	Corrugated iron doors, including fastening arrangements ..	0	10	0	s. ft.	34	
19. 140 r. ft.	6″ diameter sal bullah props ...	0	5	0	r. ft.	44	
20. 1 set.	Extra labour for cutting the sloped bricks at top ..	2	0	0	L. S.	2	
21. 1 set.	Extra labour for cutting the sloped bricks of buttress	4	0	0	L. S.	4	
22. 1 set.	Painting the plates, etc., with Bitumastic solution ...	8	0	0	L. S.	8	
23. 19·5 r. ft.	1″ diameter W. I pipes ...	0	6	0	r. ft.	7	
24. 3 Nos.	1″ brass plug cocks	6	0	0	each	18	
25. 2 Nos.	Galvanized iron drums complete ..	45	0	0	each	90	
26. 1 No.	$\frac{1}{8}$″ thick plain galvanized sheet iron rain collector and funnel ..	90	0	0	each	90	
							1,084
	Add contingencies at 5%						54
	TOTAL ...	...	..	..	...	....	1,138
	A 3-foot Drain Gauge cost Rs. 1,060.						

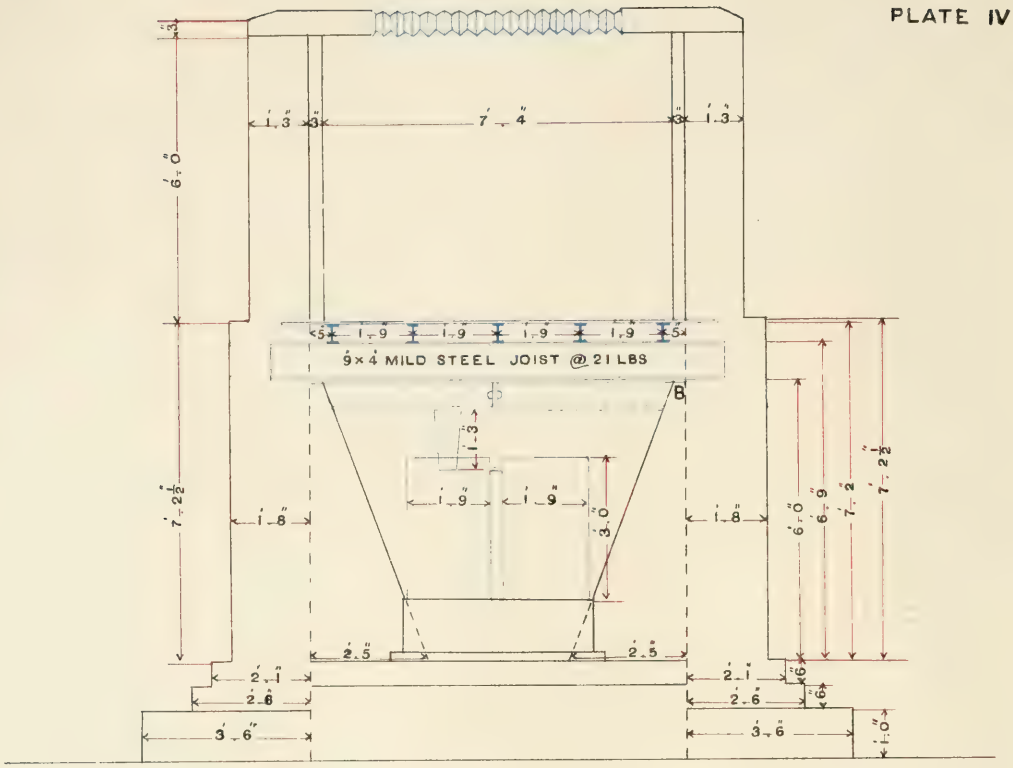
PLATE No. I.

PLATE No. II.

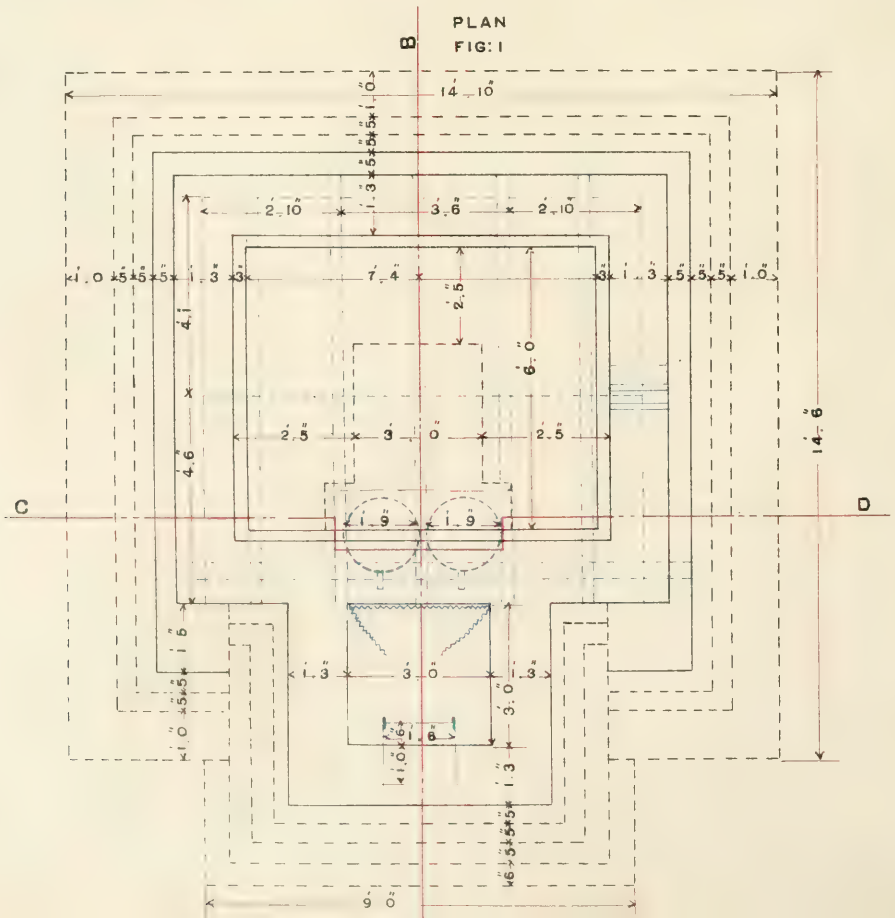
PLATE No. III.

PLATE IV

FIG: 2
SECTION ON C.D.
SCALE 4 FT. = 1 INCH



PLAN
FIG: 1



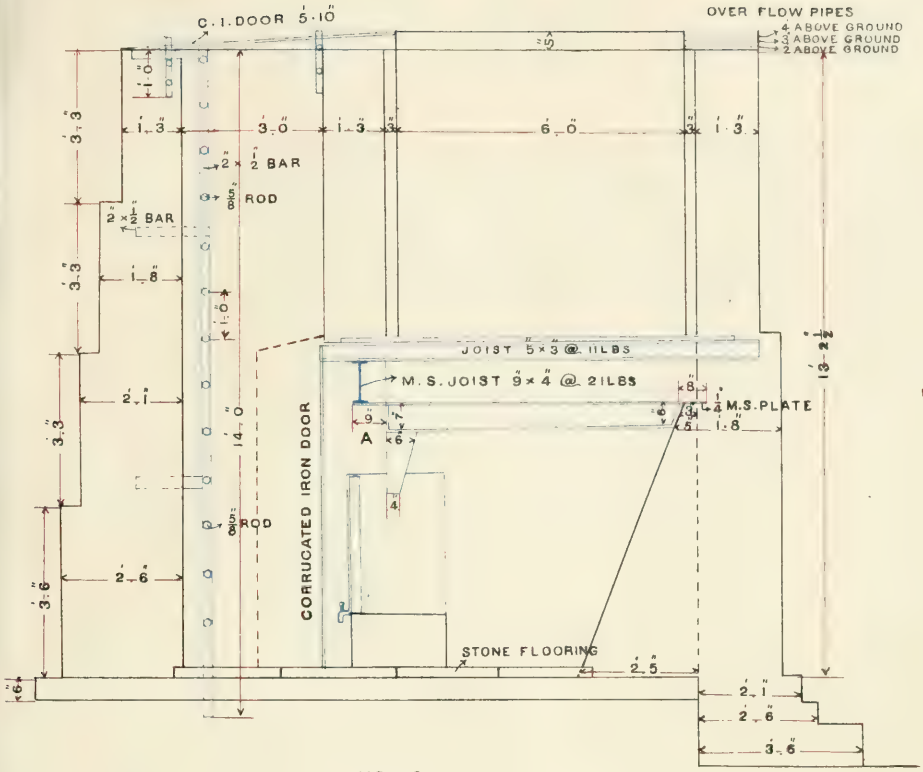


FIG: 3
SECTION ON A.B
SCALE 4"=1'

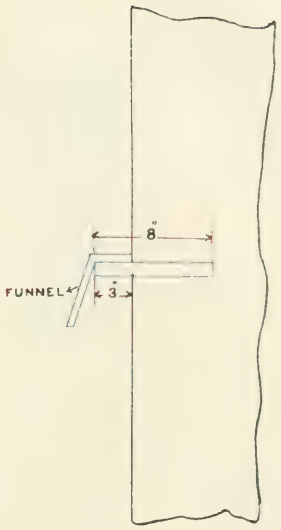


FIG: 5
DETAIL AT B.
SCALE 1 FT = 1"

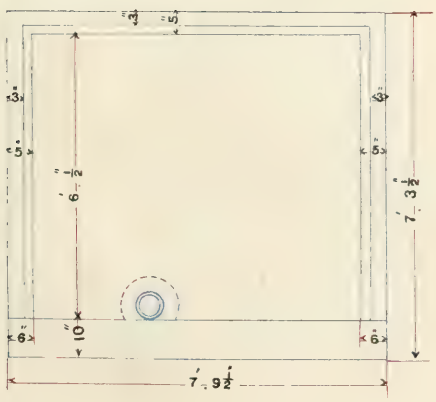
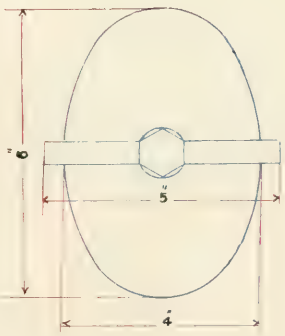


FIG: 4
PLAN OF FUNNEL
SCALE 4 FT = 1 INCH



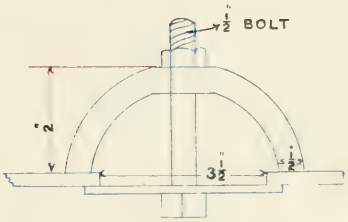
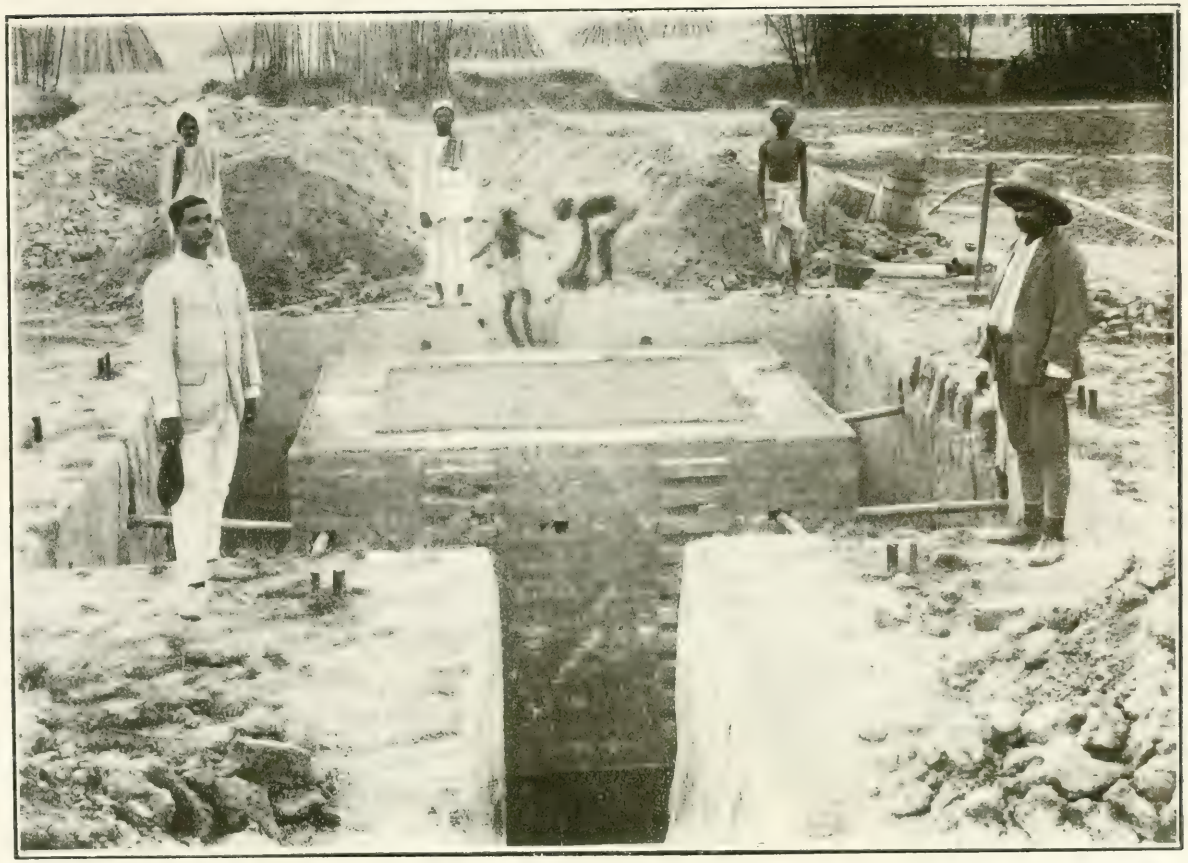
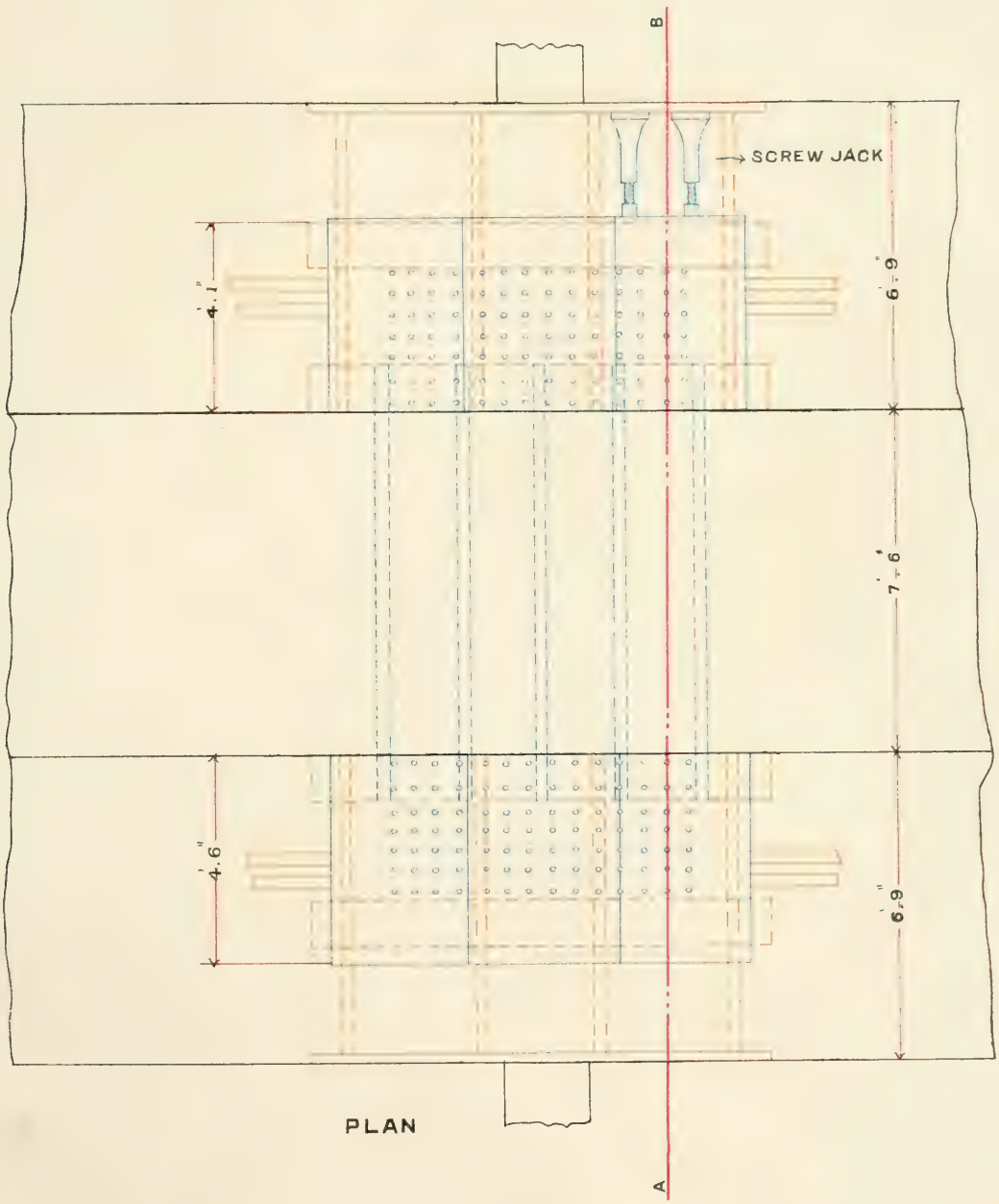


FIG: 6
DETAIL AT A OF MUD HOLE PLUG
SCALE ½ FULL SIZE

PLATE No. V.

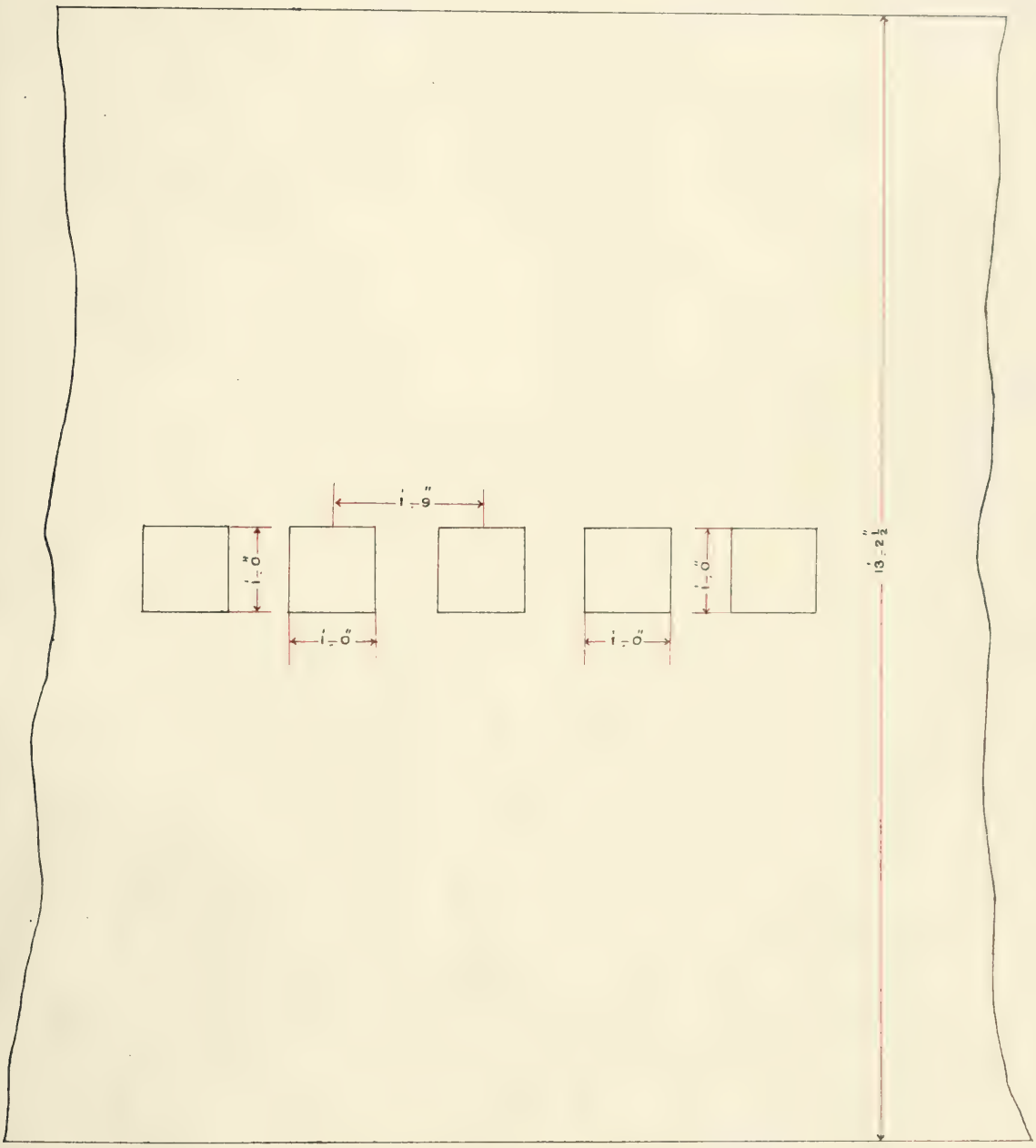


SHOWING PLATES IN POSITION AND ABOUT TO BE PUSHED HOME WITH THE SCREW JACKS
SCALE 4 FEET=1 INCH.



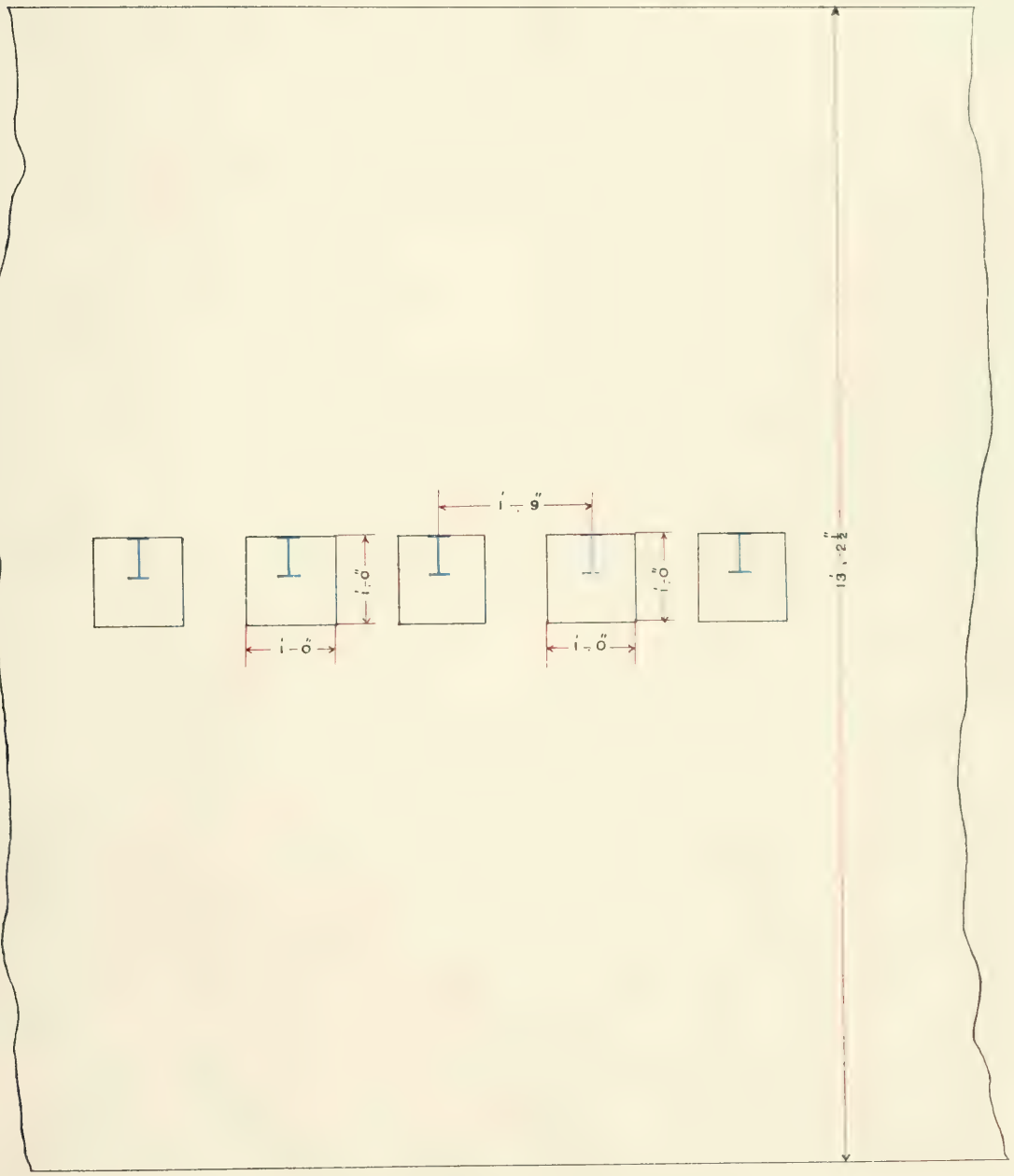
PLAN

DIMENSIONED SKETCH SHOWING JOIST HOLES.
SCALE 2 FEET = 1 INCH.



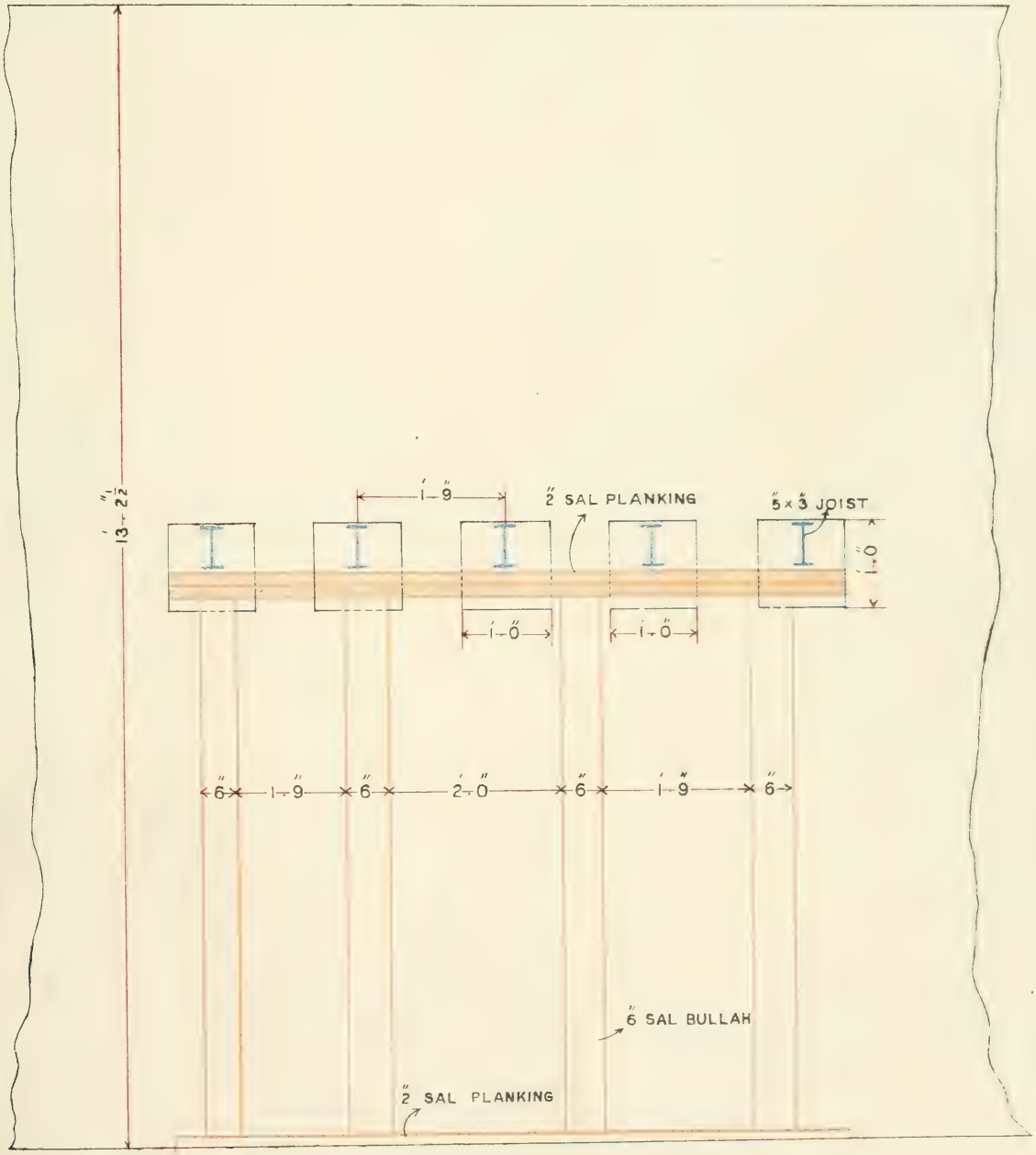
ELEVATION FROM ONE FACE.

DIMENSIONED SKETCH SHOWING JOISTS IN POSITION.
SCALE 2 FEET = 1 INCH.



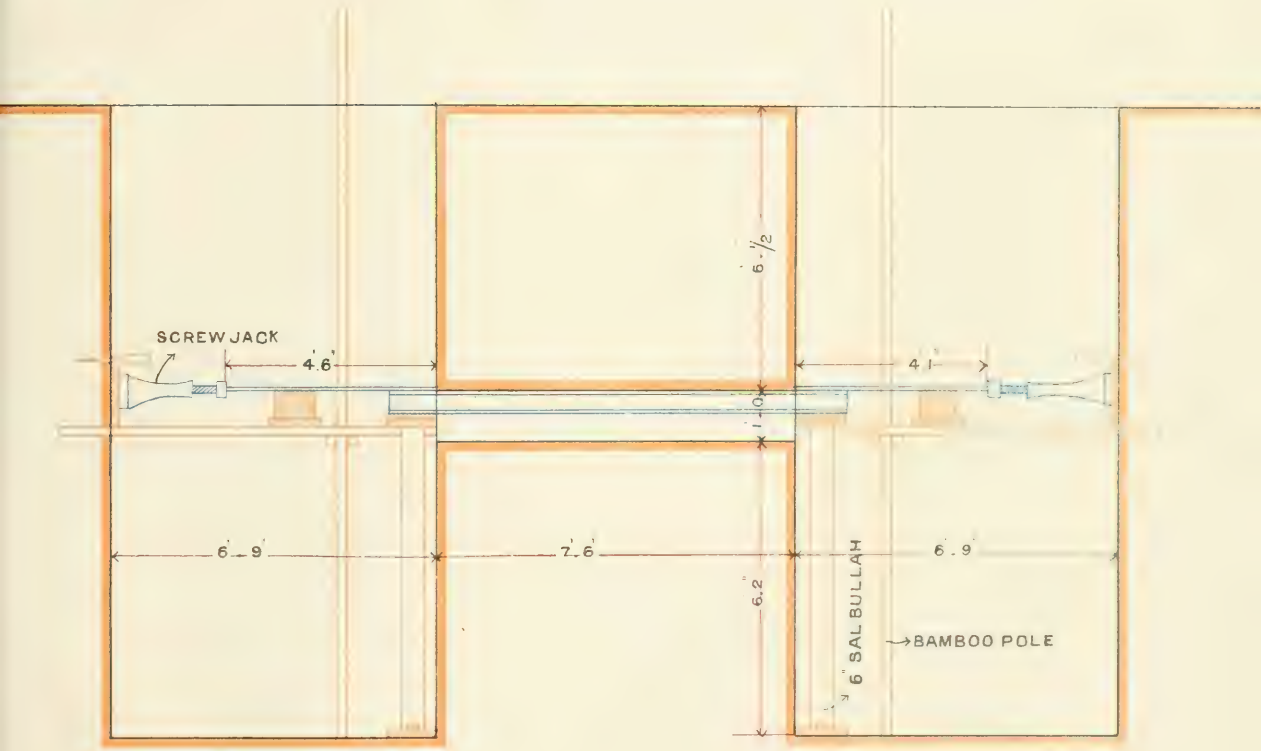
ELEVATION FROM ONE FACE.

DIMENSIONED SKETCH SHOWING JOISTS PROPPED BEFORE INSERTING THE PLATES.
SCALE 2 FT. = 1 INCH.



ELEVATION FROM ONE FACE.

DRAWING SHOWING PLATES IN POSITION AND ABOUT TO BE PUSHED HOME WITH THE SCREW JACKS
SCALE 4 FEET = 1 INCH.



SECTION ON A.B.

PLATE No. XII.

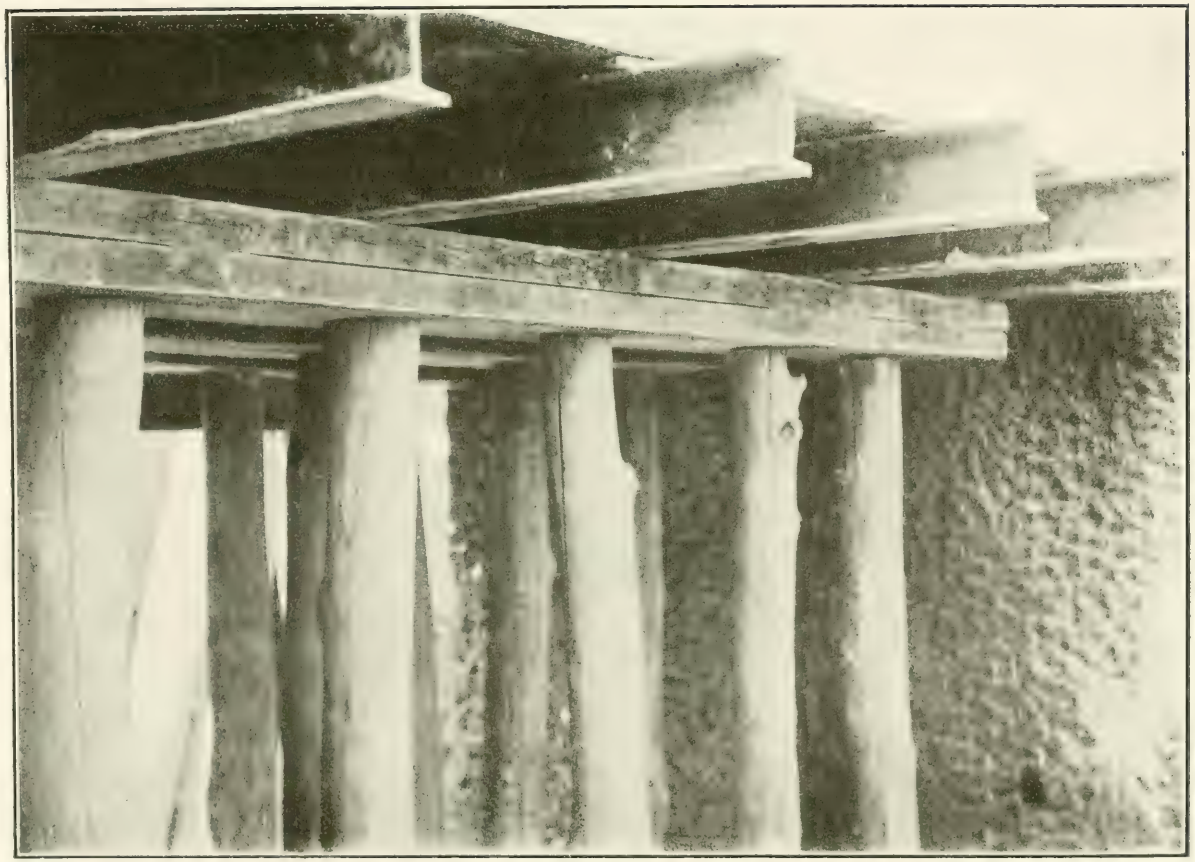


PLATE No. XIII.

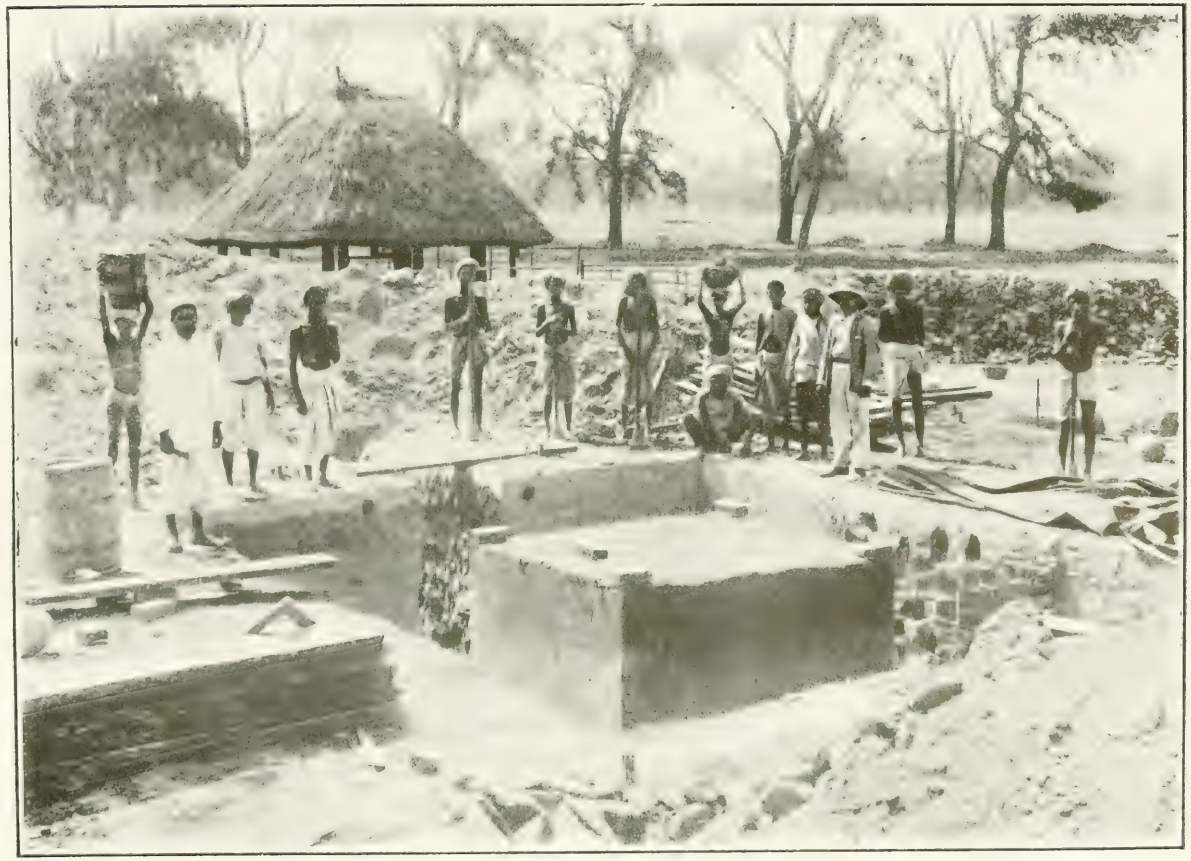


PLATE No. XIV.

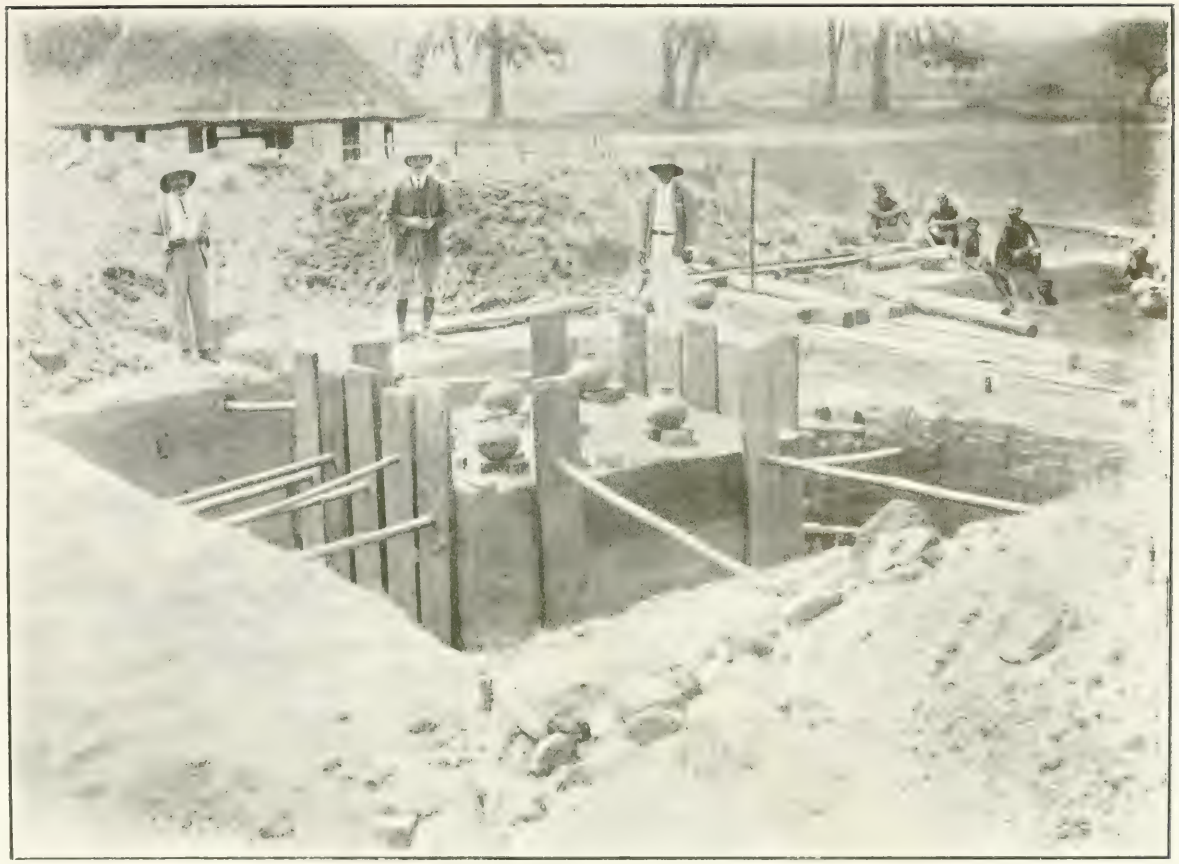


PLATE No. XV.

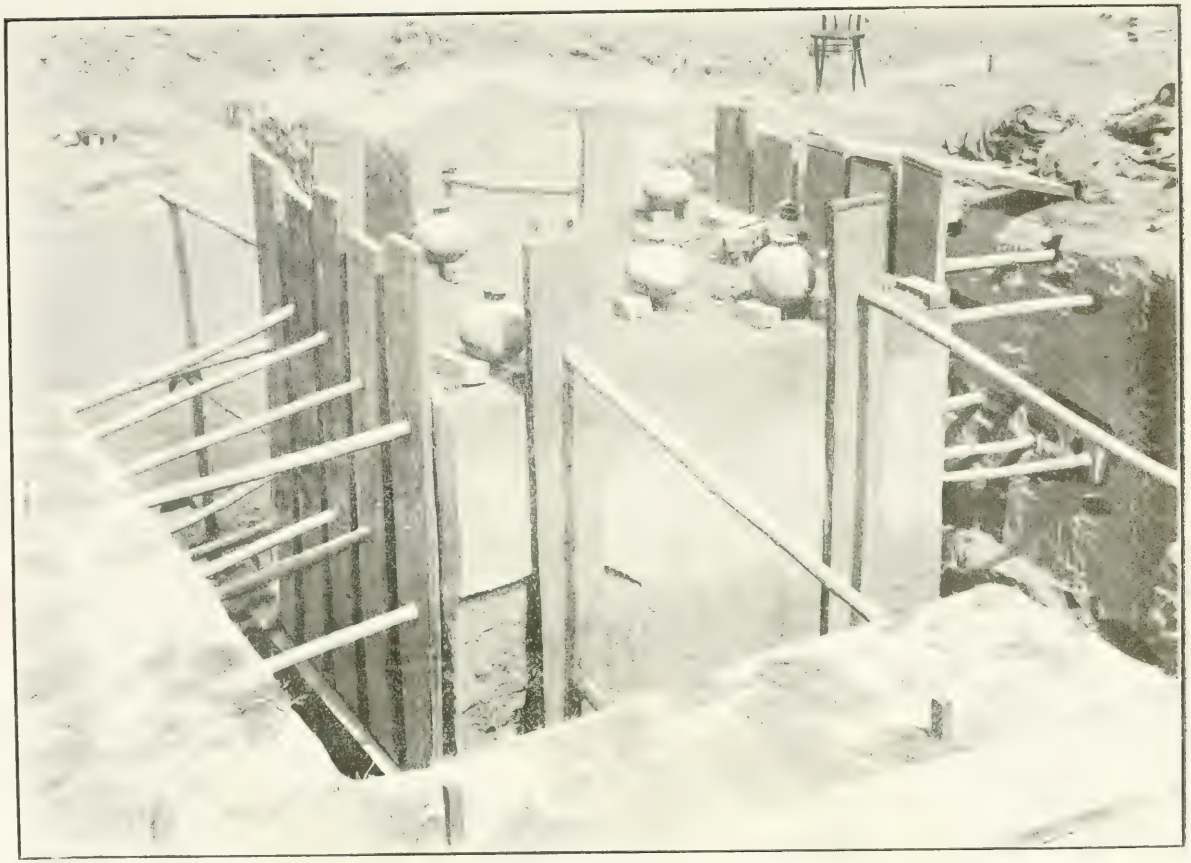


PLATE No. XVI.

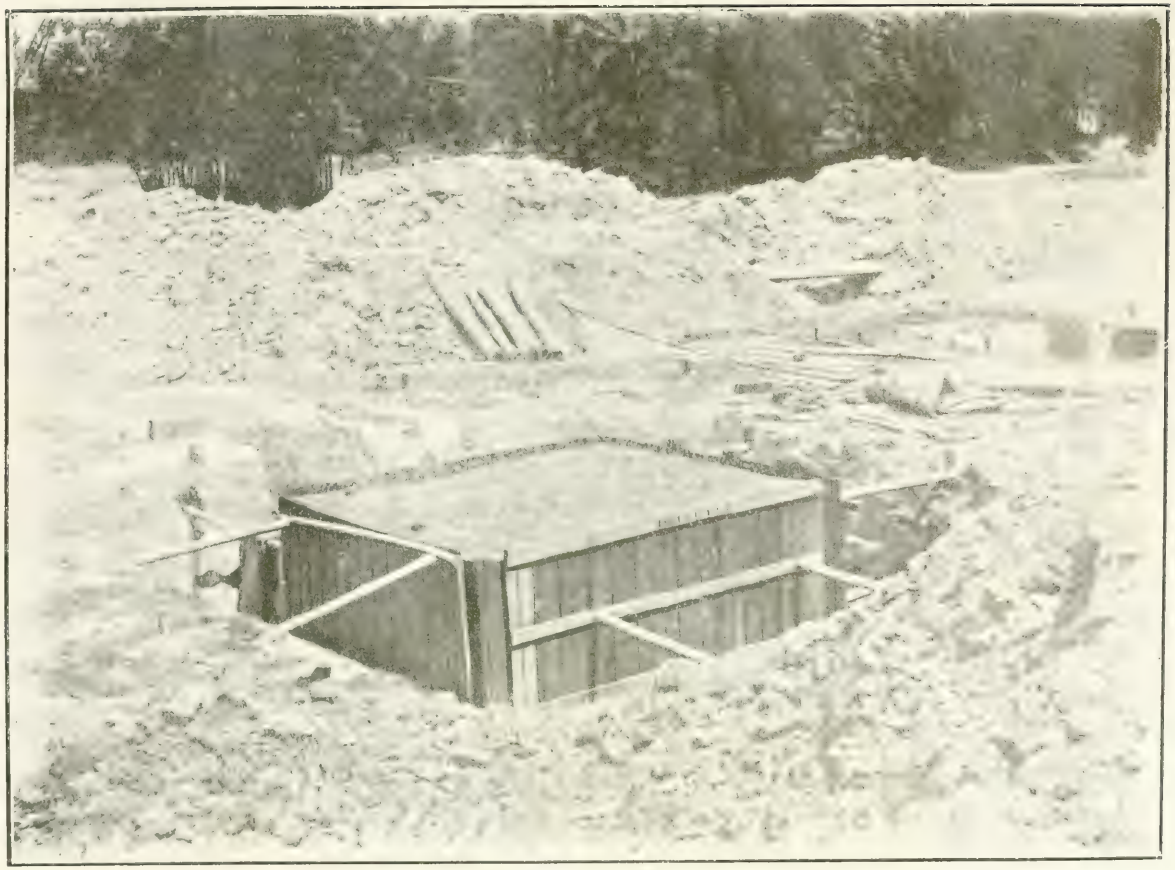
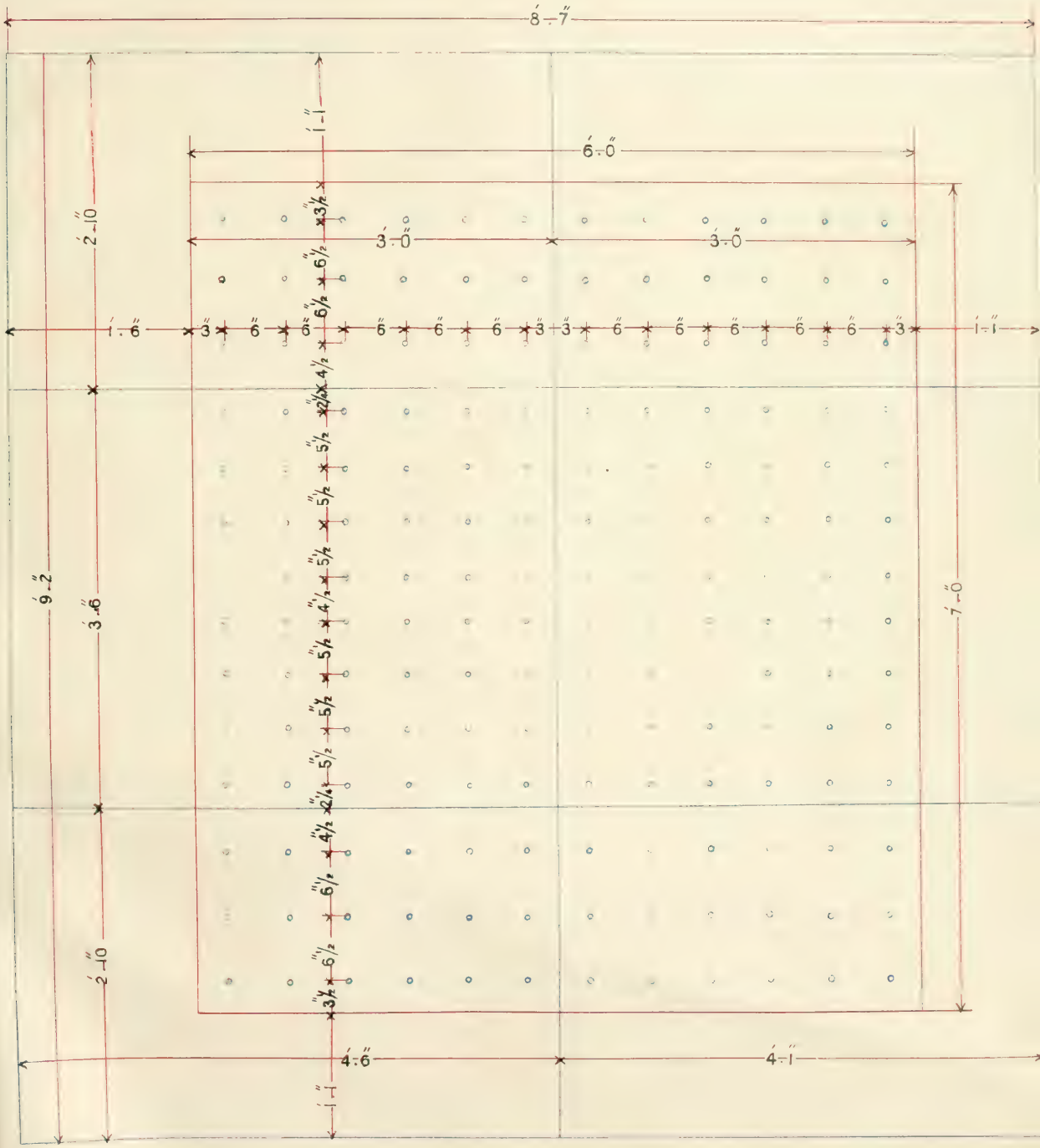


PLATE No. XVII.

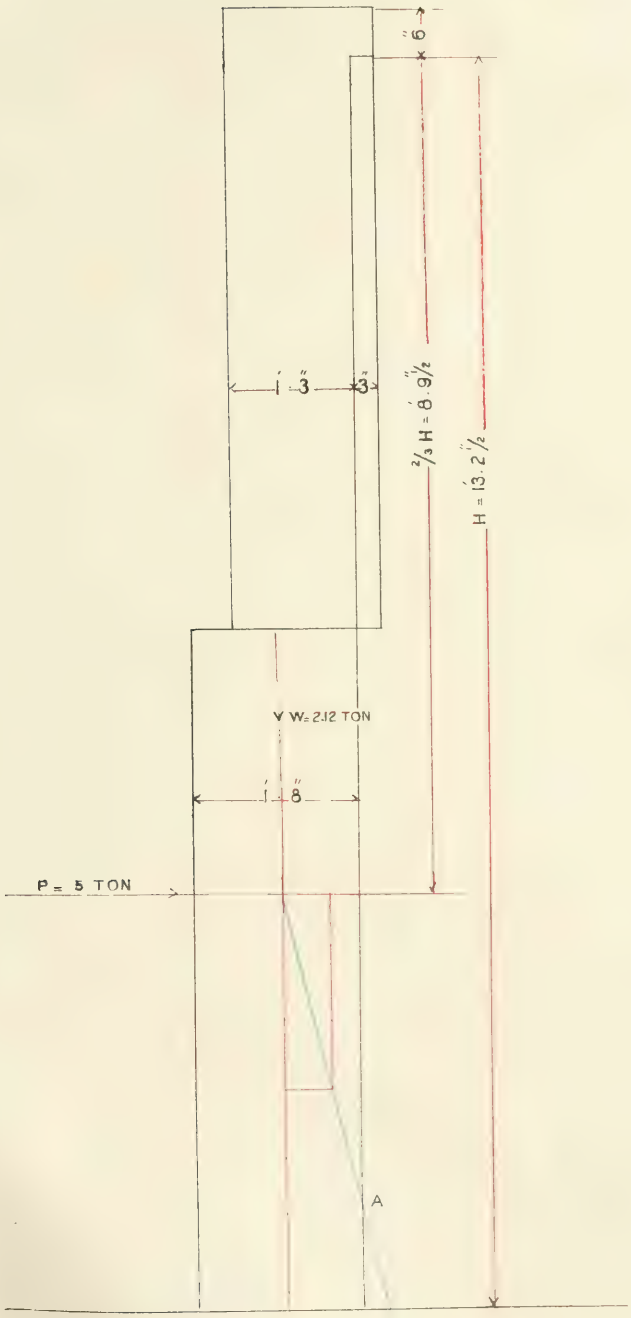
PLAN OF PERFORATED PLATE FOR DRAIN GAUGE.

SCALE ½ INCH = 1 FOOT.



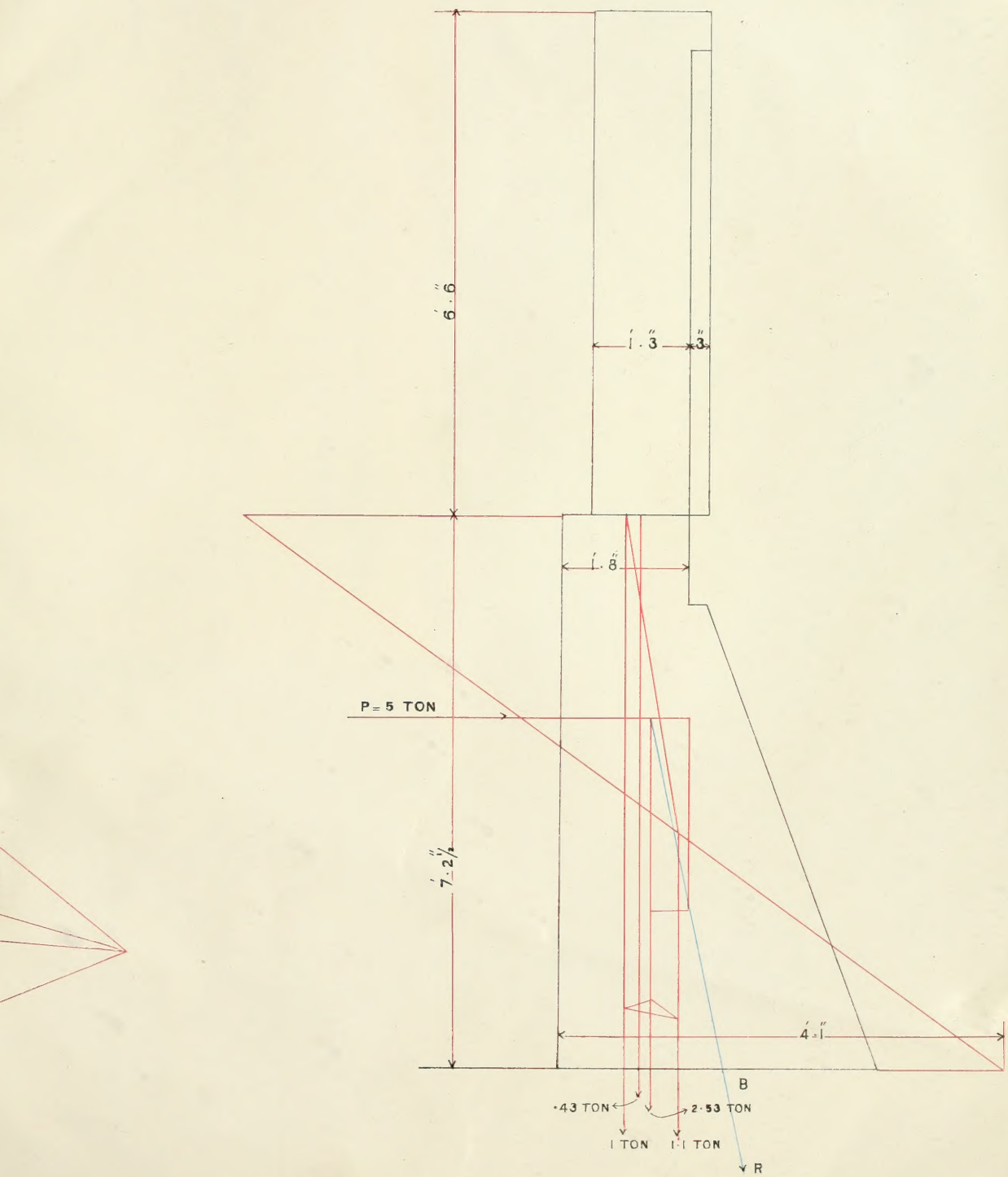
WALL WITHOUT BUTTRESS SHOWING THE LINE OF THE CENTRE OF PRESSURE FALLING OUTSIDE THE WALL AT A.

SCALE 2 FT. = 1 INCH.



WALL WITH BUTTRESS SHOWING THE LINE OF THE CENTRE OF PRESSURE FALLING WITHIN THE MIDDLE THIRD OF THE BASE AT A.

SCALE 2 FT. = 1 INCH.



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